

Assignment 5

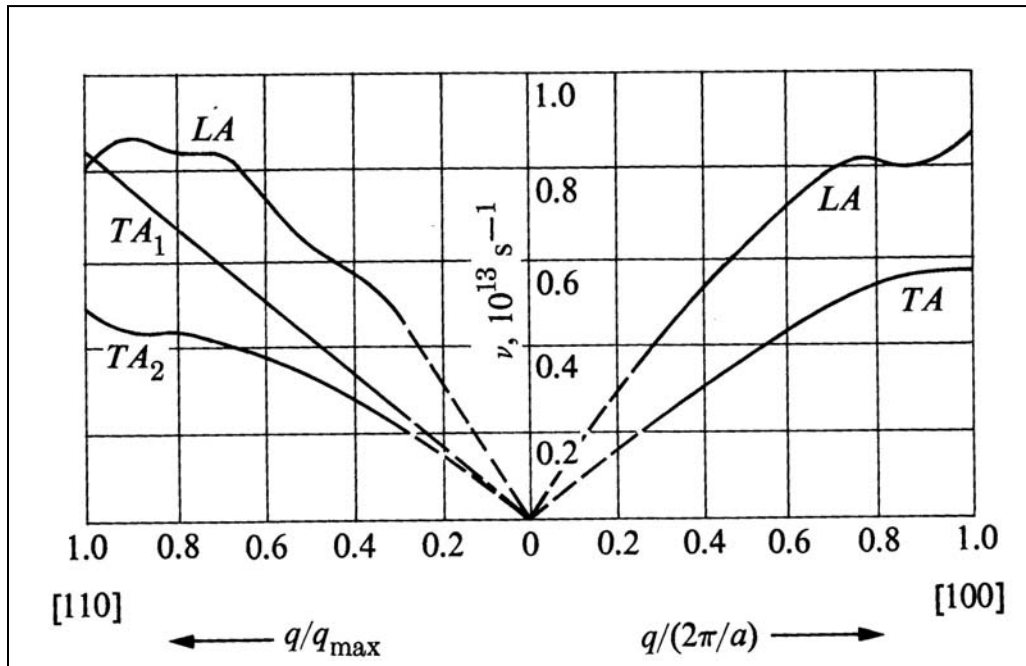
Due: Friday, Oct. 5 at 4 pm (Turn in to envelope outside my office.)

Reading: Reading: Livingston Ch. 1, 12.1, 12.2 (These were already assigned last week.)

Assigned exercises (except as noted, these are group problems, i.e. you may work on them with other students in small groups)

5A. Shown below is the dispersion relation for Al, which has an fcc structure. To the right of the origin is shown the dispersion relation for the [100] direction, while to the left of the origin is shown the dispersion relation for the [110] direction. (Note that, because each branch of the dispersion relation is individually symmetric relative to the origin, only the positive half of each branch is plotted.) The symbol “ q ” is used in place of the symbol “ k_{ph} ”. Also, the vertical axis represents frequency, rather than angular frequency. The “ TA_1 ” and “ TA_2 ” modes refer to two different transverse modes; if we define the [110] direction as the x -axis, then the TA_1 mode corresponds to oscillations along an axis perpendicular to x , which we’ll call the y -axis, while the TA_2 mode would correspond to oscillations along an axis perpendicular to both x and y .

- Explain why there is only one transverse mode shown for the [100] direction.
- Explain why there are no optical modes shown.
- Is the speed of sound isotropic (i.e. independent of direction) for Al? Explain in detail.
- Identify a region on these plots where the group velocity is negative.
- Why does the plot for the [100] direction extend to $\frac{2\pi}{a}$, instead of $\frac{\pi}{a}$?
- For the [110] direction, what is the value of q_{max} in terms of the conventional cell sidelength a ?
- For a phonon of wavelength $2a$, is the speed greatest for the TA mode in the [100] direction, for the TA_1 mode in the [110] direction, or for the TA_2 mode in the [110] direction? Explain.



Assignment continues on the next page

5B. For the TA mode of Al in the [100] direction, approximately what is the effective spring constant K for the restoring force exerted on each atom? (Express your answer numerically.)

Livingston 7-2 (individual problem)

Livingston 7-12 (individual problem)

Livingston 7-8